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RECOMMENDATIONS ON A PREFERRED SITE FOR THE OCEAN DISPOSAL OF BULKY INERT MATERIALS IN BEAUFORT SEA WATERS ADJACENT TO THE NWT

W&NR 87/88-CP(EP)-2

MAY 1987

RECOMMENDATIONS ON A PREFERRED SITE FOR THE OCEAN DISPOSAL OF BULKY INERT MATERIALS IN BEAUFORT SEA WATERS ADJACENT TO THE NORTHWEST TERRITORIES

Environmental Protection
Conservation and Protection
Environment Canada
Yellowknife, N.W.T.

May 1987

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1. INTRODUCTION

Industrial operators in the Beaufort Sea region have noted a requirement to dispose of inert waste materials generated by hydrocarbon exploration or production activities. These materials (for which ocean dumping approval has been or will be sought) include empty 204.5 l drums, discarded drilling equipment, miscellaneous scrap, and drilling caissons. While acknowledging operators' disposal requirements, Environmental Protection (EP) has indicated that ad hoc ocean dumping decisions could lead to a proliferation of small dumpsites or, conversely, the establishment of a dumpsite at the first dumping location, whether or not that site has been adequately assessed. Neither situation was considered by EP to be acceptable. Therefore, in 1982/83, EP began a process to assess the ocean disposal option for inert wastes in the context of an overall inert waste management program. The ultimate goal of this process has been to select a preferred site for ocean disposal of inert wastes in the Beaufort Sea.

The ocean dumpsite program has been undertaken with the assistance and advice of the Regional Ocean Dumping Advisory Committee (RODAC). By undertaking this program in advance of a specific dumping proposal, it was felt that any potential impacts could be impartially assessed and site selection would not be influenced by the immediate needs of specific operators.

The ocean dumpsite selection process began with a dumpsite feasibility study carried out for EP by Dillon Consulting Engineers and Planners (1983). Following that study, a workshop was held to evaluate draft criteria for dumpsite selection and to identify information requirements (Thomas, 1984). Subsequently, an assessment of constraints to dumpsite selection and recommendations for preferred dumping sites was completed (Environmental Protection, 1986).

As a result of these activities, an area near the submerged Kugmallit Valley north of Tuktoyaktuk was identified as the preferred region within which a specific dumpsite should be selected. Several potential dumpsites were reviewed at a May 1986 meeting of RODAC. Following that meeting, EP focussed its attention on one site in waters adjacent to the Northwest Territories on the continental slope north of the Pullen pingo area. Before a decision on the site's suitability could be made, however, EP made a commitment to a biological, physical, and geochemical characterization of the recommended site. The dumpsite characterization study was carried out in late August, 1986, during a one week cruise aboard the Fisheries and Oceans research vessel "J.P. TULLY".

The intent of this report is to provide an overview of the factors considered during the ocean dumpsite selection process and to establish the rationale for the selection of the Pullen location as an offshore waste disposal site. This document reviews the environmental, economic, and navigational factors considered during the dumpsite selection process and summarizes the physical, biological, and geochemical data obtained during the 1986 dumpsite characterization survey.

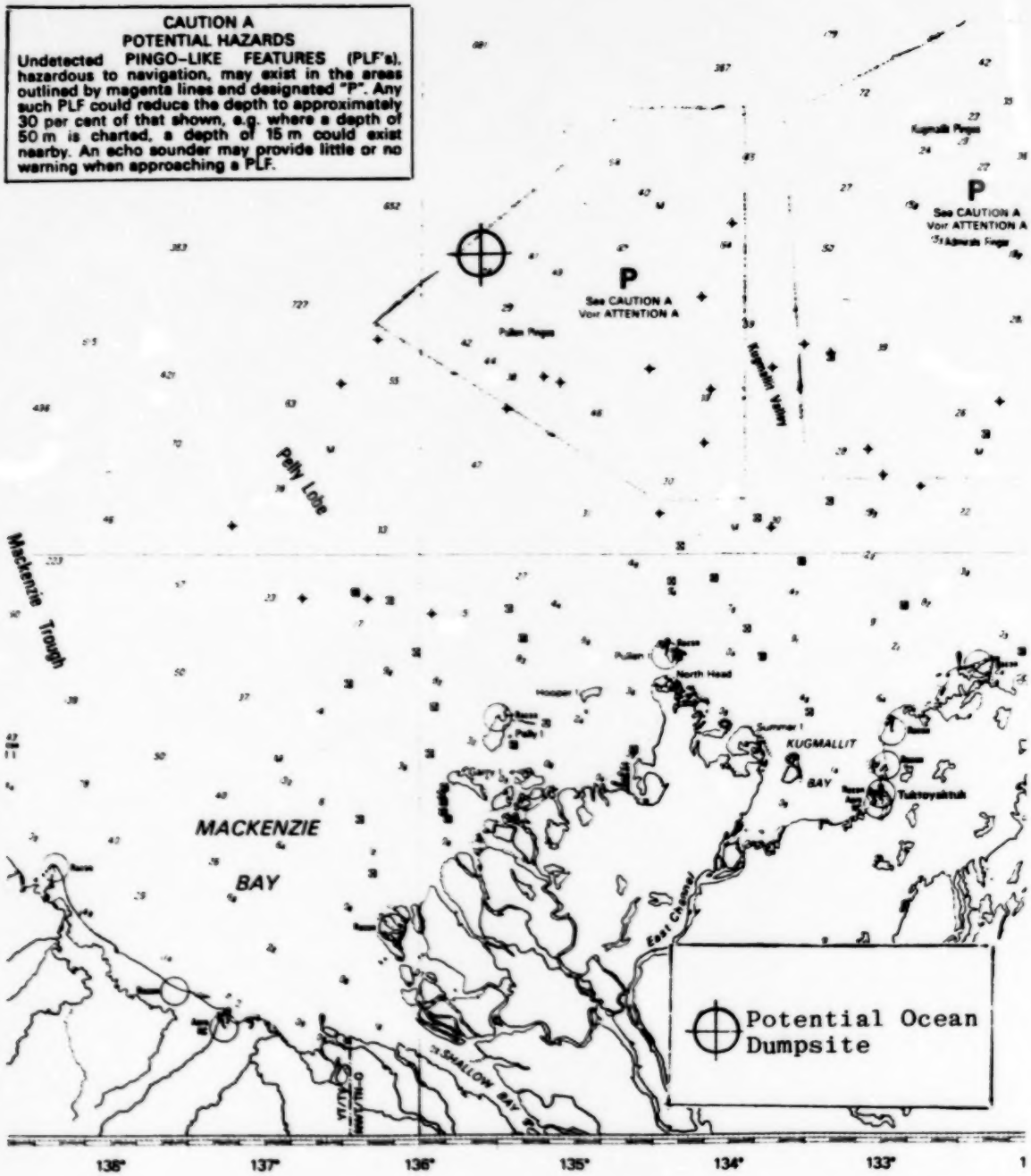
2. RECOMMENDED SITE LOCATION

Figure 1 indicates the location of the recommended dumpsite. The site is centered at 70° 39'N, 135° 50'W, approximately 145 km northwest of Tuktoyaktuk. Actual dumping at the site would be restricted to within a 1.5 km radius of the dumpsite centre.

3. MATERIALS TO BE DUMPED

Materials placed at the ocean dumpsite would be comprised of scrap metal and other "inert" wastes as summarized in Table 1. Inert materials are assumed to have very limited chemical and biological reactivity. Their reaction rates and reaction products would therefore not cause significant environmental alterations (Environmental Protection, 1986).

The working group participating in Phase I of the ocean dumpsite designation process estimated the quantity of inert wastes to be dumped in the Beaufort Sea at 375,000 tonnes over 75 years (Thomas, 1984). For review purposes, this quantity was increased by a factor of ten to 3,750,000 tonnes in order to provide a substantial safety margin. The actual quantity of inert wastes produced by Beaufort Sea operators will likely be substantially less than the forecast amount, although the precise quantity will depend on future levels of industrial activities . An unpublished EP survey estimated the quantity of scrap metal stored at Tuktoyaktuk support bases to be greater than 1900 tonnes, not including an undetermined quantity of metal used in the Tarsiut Island caissons (Table 1). These estimated quantities are probably very conservative, since Esso alone has applied to dump 2000 tonnes of scrap and has recently applied to dump its drilling caisson as well. Gulf has applied for an ocean dumping permit to dispose of the Tarsiut Island caissons and 400 tonnes of miscellaneous scrap metal. Permit applications may also be forthcoming from Dome and Panarctic Oils Limited to dump used drilling equipment and scrap metal.


CAUTION A
POTENTIAL HAZARDS
Undetected PINGO-LIKE FEATURES (PLF's), hazardous to navigation, may exist in the areas outlined by magenta lines and designated "P". Any such PLF could reduce the depth to approximately 30 per cent of that shown, e.g. where a depth of 50 m is charted, a depth of 15 m could exist nearby. An echo sounder may provide little or no warning when approaching a PLF.
P
See CAUTION A
Voir ATTENTION A
Kugmallit Valley
Pelly Lobe
Mackenzie Trough
MACKENZIE
BAY
KUGMALLIT
BAY
North Head
East Channel
SHALLOW BAY
Potential Ocean Dumpsite
138°
137°
136°
135°
134°
133°

Source: Canadian Hydrographic Service
Chart No. 7600

Figure 1.Potential Ocean Dumpsite Location

TABLE 1: CURRENT AND ANTICIPATED QUANTITIES OF INERT WASTES FROM BEAUFORT SEA OPERATORS

Operator	Waste Types	Amount Stored	Anticipated Amounts of Waste Generated Per Year
Arctic Transportation Limited	- vessel (MV Arctic Ublureak)	Length 43 metres Beam 11 metres Height 16 metres 272 tonnes	-----
	- vessel (MV Arctic Pelly)	Length 52 metres Beam 12 metres Height 13 metres 690 tonnes	------
	- wire rope	50 tonnes	50 tonnes
Dome Petroleum Limited	- scrap metal	500-1000 tonnes	-----
Esso Resources Canada Limited	- scrap metal	300+ tonnes	100 tonnes
	- drilling caisson	Diameter 116 m Height 16.5 m 12,000 tonnes	
Beaudril Limited	- scrap metal	450 tonnes	250 tonnes
	- Tarsiut Island caissons	Length 69 metres Width 15 metres Height 12 metres	-----

Source: Unpublished EP data, 1985.

4. PHYSICAL, GEOCHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF THE POTENTIAL DUMPSITE

4.1 Dumpsite Bathymetry, Surface Features, and Subsurface Profile

Figure 2 displays seabed contours (using a 10m contour interval) within the proposed dumpsite area as determined by the Canadian Hydrographic Service (CHS) during the August, 1986 cruise (Arctic Laboratories, 1987). The regional slope over the dumpsite is approximately 1 in 37, or an angle of about 1.55°. Water depths range from 120m in the southeast sector to 300m at the north-northwestern edge of the site.

Seabed features recorded by sidescan sonar coverage of the site consist of a single "pock mark" (commonly associated with venting of subsurface gases through soft marine sediments) and numerous small, linear depressions (1 to 3m in width and 5 to 15m in length) which do not appear related to any geologic phenomenon. The latter features seem to be randomly distributed, with a density of about 5 to 20 features per square km. In most cases, these depressions are oriented parallel to the bathymetric contours.

Within the shallow subsurface sediments of the potential dumpsite area, acoustic profile records show a sequence of soft marine sediments ranging between 38 and 60m in thickness. The sediments are uniformly layered to these depths and show no evidence of slumping or sliding within the dumpsite radius. As well, the layered character of these sediments indicates deposition under relatively quiescent conditions, with little or no influences from currents or other active processes (Arctic Laboratories Limited, 1987).

Because the potential dumpsite is situated in waters deeper than 120m, surface navigation in the area would not be impaired. The Navigable Waters Protection Act restricts ocean disposal in navigable waters to areas where a minimum of 37m will remain between the water surface and the top of the disposed materials. Assuming an average 2m thickness of disposed waste materials on the substrate (Environmental Protection, 1986), post-dumping depths would not restrict navigation. Even unusually bulky items such as vessels or drilling caissons could safely be placed within the dumpsite without interfering with subsequent surface navigation.

The site is located in an area which should be free from ice scouring. Therefore, the wastes would not be re-distributed by ice movement after disposal. Generally, evidence of scouring is most prevalent shoreward of the 50m isobath. In waters deeper than 50m, ice scouring is very uncommon since ice keels rarely extend beyond that depth. Ice

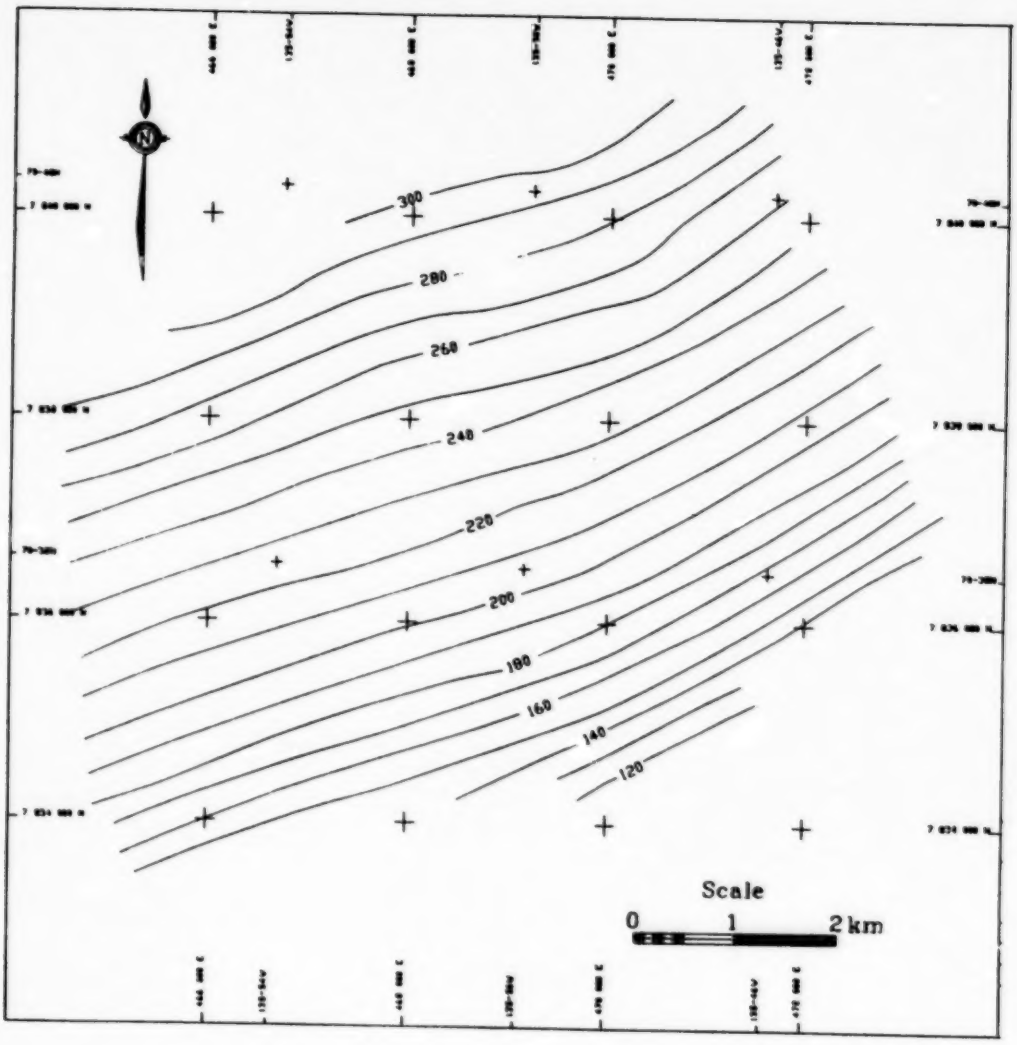


Figure 2. Bathymetry of Potential Dumpsite
(contours in metres)

scours noted below 50m are believed to have been made during or just after the last period of glaciation when sea levels were lower than at present. The deepest ice keel recorded in recent times in the Beaufort Sea had a draft of 47m (Lewis, 1977; Parker and Alexander, 1983). Ice scouring was not apparent in any of the side-scan sonar records, during the 1986 EP field study (Arctic Laboratories Limited, 1987).

It is also preferable that the potential dumpsite not be located in an area of slope instability. Placement of material on an unstable slope could lead to slope failure and consequent disruption of bottom conditions or redistribution of disposed material. The edge of the Beaufort Sea continental shelf west of 132° longitude is known to be an area of relative slope instability. O'Connor (1981) described scarps, slump debris and dislocated strata at the shelf edge and continental slope near 136° 30' longitude, indicating significant downslope movements of surficial sediments in the recent geologic past.

Subsurface acoustic profiles indicate that the sediments at the potential dumpsite are soft and possess a high water content (Lewis, 1987). However, side-scan sonar coverage of the area did not furnish any evidence of surface sediment movement. This, coupled with the gentle average gradient (1.55°) suggests that localized slumping is unlikely to occur during or after the onset of dumping.

4.2 Trace Metal and Hydrocarbon Concentrations in Dumpsite Sediments

The proposed dumpsite area has not been subjected to any known dumping activities or discharges from industrial operations. Therefore, measured levels of trace metal and hydrocarbon contaminants in dumpsite sediments should represent natural, background concentrations.

Table 2 presents the means and standard deviations for trace metals, total alkanes, and total PAH's in dumpsite sediments. These trace metal, total alkane, and total PAH levels are within the ranges reported in previous studies of Beaufort Sea sediments (Hoff and Thomas, 1986). None of the dumpsite sediment samples contained concentrations of Schedule I materials in excess of regulated limits established pursuant to the Ocean Dumping Control Act.

TABLE 2: CONCENTRATIONS OF TRACE METALS, TOTAL ALKANES, AND TOTAL PAH'S IN SURFACE SEDIMENTS AT THE POTENTIAL DUMPSITE (ug/gm).

Parameter	Mean	Standard Deviation	Number of Samples
Lead	23.4	2.7	20
Nickel	36.5	3.9	20
Mercury	0.072	0.014	20
Copper	34.1	3.2	20
Zinc	136	13	20
Cadmium	0.1	0.02	20
Chromium	131	10	20
Barium	866	34	20
Total Alkanes	6.4	1.8	19
Total PAH	0.66	0.078	18

5. ICE CONDITIONS

In the Beaufort Sea, disintegration of landfast ice normally begins in June, with the coastal open water corridor expanding throughout the summer. The number of floes in the transition ice zone reaches a maximum in early summer; however, further melting reduces the number and size of floes until the maximum area of open sea is attained in early September.

For industry, the utility of ocean dumpsites will, in part, be determined by their accessibility. Site accessibility (or "working season length) has been defined by Spedding (1978) as the period when ice cover is less than one- tenth of the sea surface and vessel access to or exit from a shore staging area is not impeded by landfast ice. Based on these assumptions, and an analysis of 1959 to 1977 Beaufort Sea ice data, Spedding (1978) showed July 27 to be the mean earliest date on which a site centered on 130° 30'W and the 60m isobath would be accessible with the earliest date being July 2. During three summers, (1964, 1967, 1974), ice concentrations greater than one-tenth were present at that location throughout the summer. Data for the years 1960 to 1977 indicate that after break-up incursions of ice (concentrations from 1/10 to 10/10) at the site occurred for an average of 1.27 weeks per year, with a probability of a one-week incursion during any particular year estimated at 14.5%. The average gross working season length (excluding periods of ice incursion) was calculated to be 61 days at the 135° 30'W/60m isobath intersection. Unfortunately, the working season length, ice cover, and frequency of ice incursions for locations beyond the 60m isobath were not analyzed by Spedding (1978). However, an atlas of regional ice concentrations (Markham, 1981) based on ice data acquired between 1959 and 1974 indicates median ice cover at the proposed site (70° 39'N, 135° 50'W) to be less than two-tenths between the first week of August and the first week of October (Figures 3 through 5).

6. BOTTOM CURRENTS

Bottom currents at the potential dumpsite could be considered a concern if velocities were sufficient to displace materials after dumping.

To date, no data are available regarding the speed or directional distribution of near-bottom currents at the specific dumpsite location. Existing near-bottom current data in the vicinity of the dumpsite are limited to two sets of measurements recorded near the continental shelf break southwest of the dumpsite (Figure 6).

Source: Markham, 1981.

Figure 3. Median Ice Concentration (Tenths), 30 July.

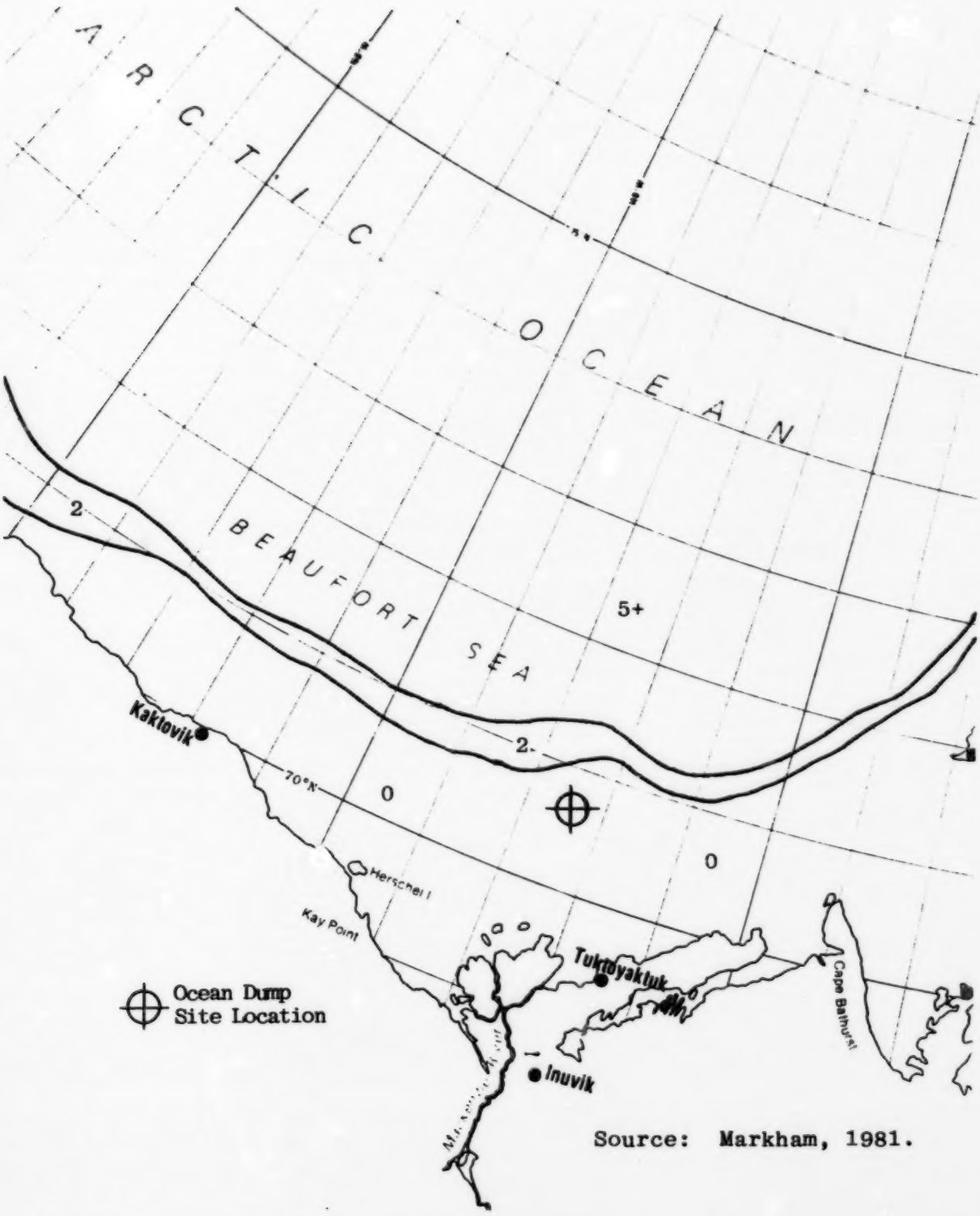


Figure 4. Median Ice Concentration (Tenths), 10 September.

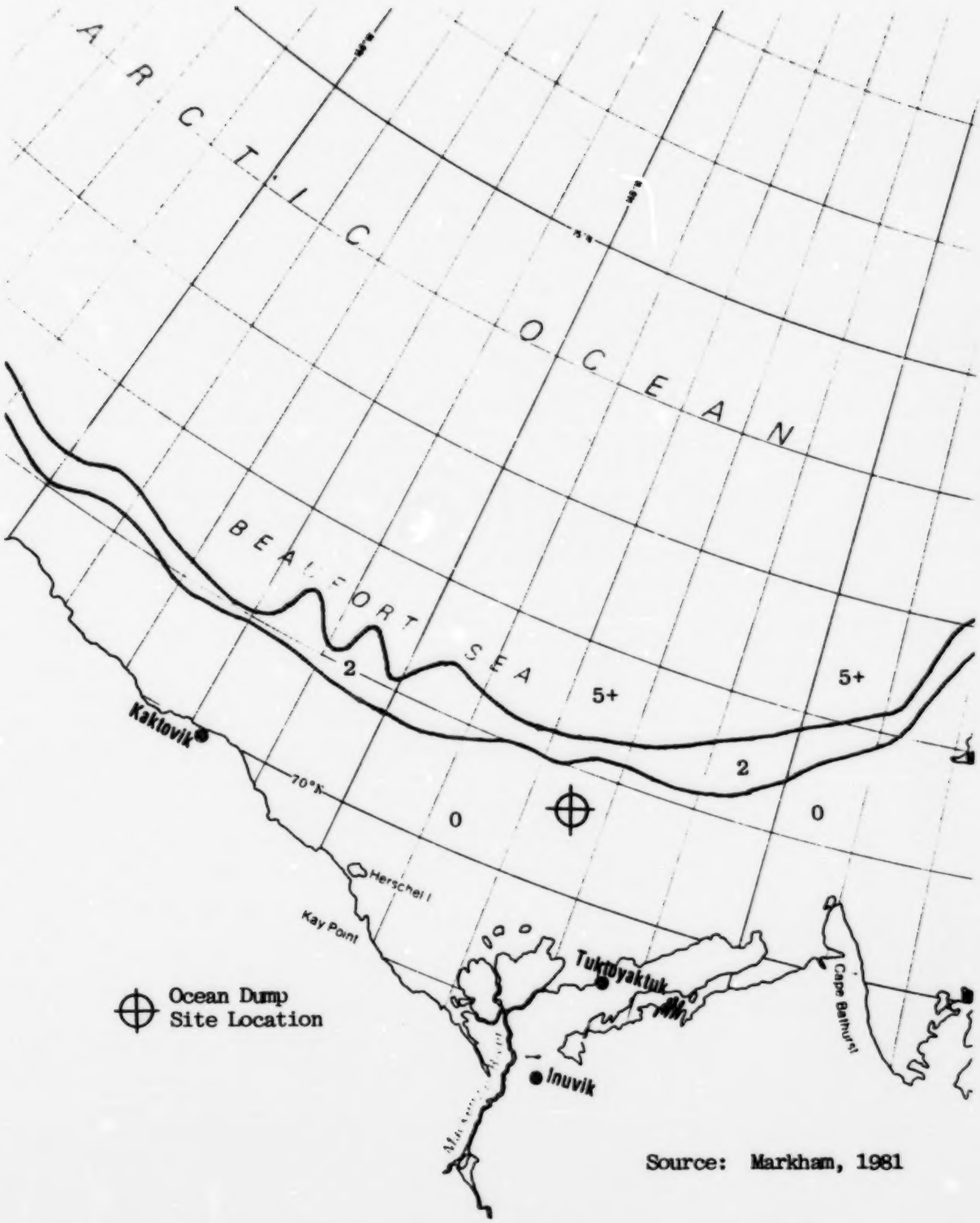


Figure 5. Median Ice Concentration (Tenths), 24 September.

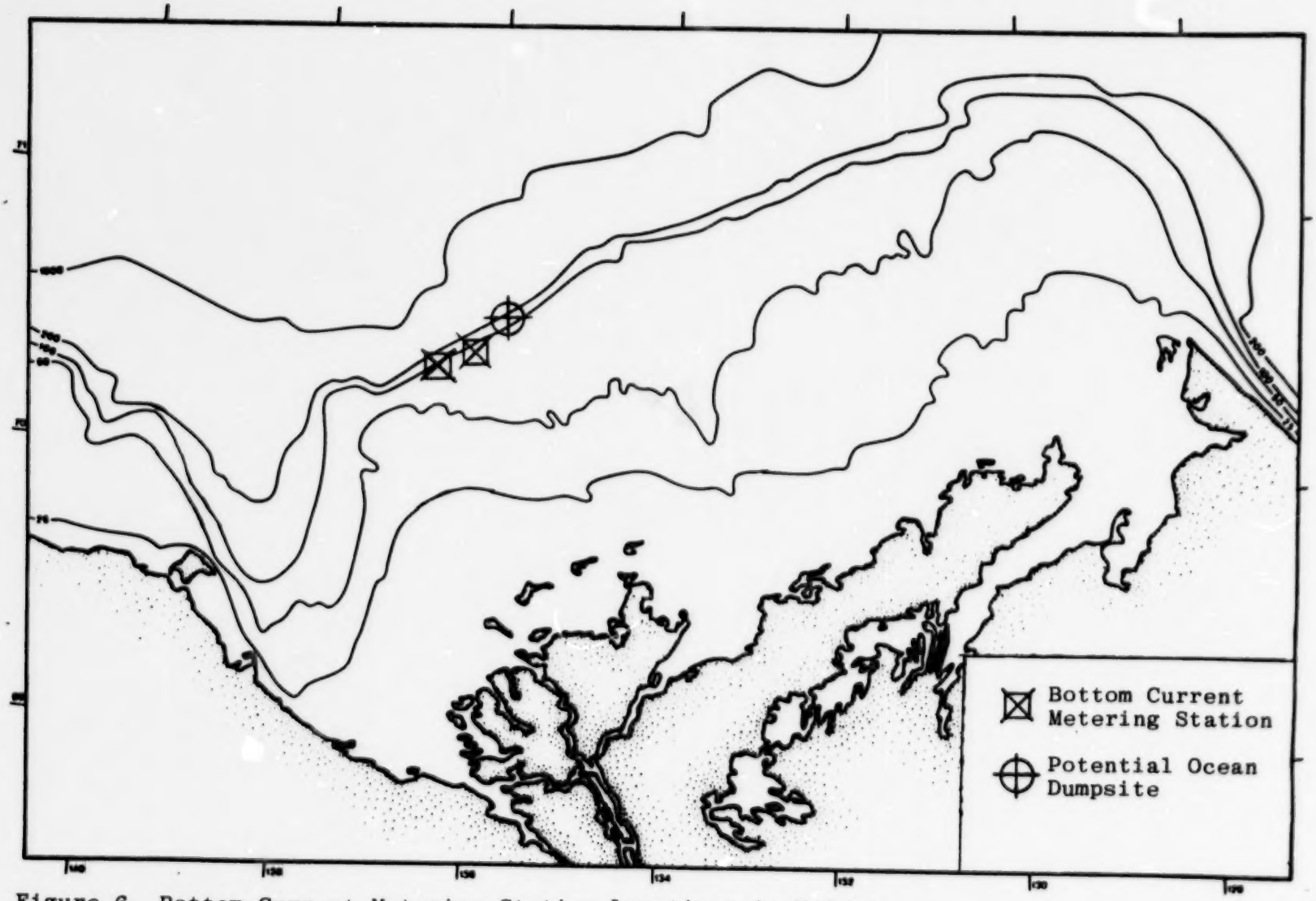


Figure 6. Bottom Current Metering Station Locations in Relation to Potential Dumpsite Location

Between July and September, bottom currents along the upper slopes of the continental shelf west of the dumpsite tend to move in an eastward direction (Fissel and Birch, 1984). Mean current velocities at these metering stations (positioned at 70° 23.1'N, 136° 45.7'W and 70° 28.6N, 136° 16.9'W) range between 7.4 and 10.8 cm/s, with maximum velocities reaching between 22.6 and 40.9 cm/s. Unfortunately, the short duration of data collection (60 days) at these metering locations precludes estimates of extreme 10 or 20 year bottom current events. It is not anticipated that these currents would be strong enough to displace most bulky inert material; however, uncrushed oil drums and barrels could be rolled during extreme current events (B. Smiley, pers. comm.).

7. GOVERNMENT POLICIES AND LEGISLATION

Several government policies and pieces of legislation influence the selection of a Beaufort Sea dumpsite. Table 3 lists these Acts and policies and outlines their relevance to offshore dumpsite selection.

A fundamental premise of the ocean dumpsite program is that the nature of disposed wastes will conform to the requirements and regulations outlined in the Ocean Dumping Control Act, Fisheries Act, Arctic Waters Pollution Prevention Act, and the Navigable Waters Protection Act. The remaining legislation and policies define acceptable locations for ocean dumpsites, primarily by eliminating specific areas from further consideration. The Fisheries Act and Navigable Waters Protection Act stipulate that disposed materials must not adversely affect fish habitat or navigation, respectively. In keeping with these conditions, the potential dumpsite is situated in an area which is not known to be uniquely important fish spawning and rearing habitat, and in waters significantly deeper than the 37m draft clearance required for surface traffic (even after allowing for large stuctures such as vessels or caissons).

National Parks initiatives may result in the withdrawal of specific offshore areas from development activities with a view to placing these areas within the national park system. Similarly, the Department of Fisheries and Oceans proposal for a "whale management area" near the mouth of the Mackenzie River may result in restricted industrial activity in that area. To avoid conflicts with these initiatives, the proposed dumping site is located outside the areas where national parks and a whale management area might be established.

TABLE 3: LEGISLATIVE ACTS AND POLICIES BEARING UPON THE OCEAN DUMPSITE SELECTION PROCESS

Act or Policy	Area of Jurisdiction	Relevance to Dumpsite Selection Process
Ocean Dumping Control Act	All ocean waters	Regulates all disposal of waste in marine environment (except wastes from land-based sources). Identifies wastes requiring a dumping permit: ships, aircraft, and other man-made structures; containers and scrap metal; bulky substances which may interfere with fishing; materials possibly affecting other uses of the sea.
Arctic Waters Pollution Prevention Act	All Canadian waters north of 60th parallel	Prohibits deposit of any waste (any substance impairing the usefulness of water) in northern waters except by permit.
Navigable Waters Protection Act	All navigable waters within Canadian jurisdiction	Prohibits building or placement of any substance in or under a navigable water body except by permit. Restricts ocean disposal to areas where navigation would not be affected (i.e. depths greater than 37 m).
Fisheries Act	All Canadian waters	Prohibits deposition of any deleterious substance into waters frequented by fish. Also provides authority to set regulations for the purpose of protecting fish habitat.

TABLE 3: LEGISLATIVE ACTS AND POLICIES BEARING UPON THE OCEAN DUMPSITE SELECTION PROCESS (Continued)

Act or Policy	Area of Jurisdiction	Relevance to Dumpsite Selection Process
DFO Proposal for "Whale Management Area"	Vicinity of Mackenzie River outlets from King Point to Pullen Island	May restrict development activities in proposed management area.
National Parks Initiatives	Tuk Peninsula - Baille Island - Kugmallit Bay	Area identified as a Marine Natural Area of Canadian Significance (NACS) for National Landmark status; ocean dumping would be prohibited if the area was to become a marine park, but no such proposal is contemplated.
	Submarine Area 160 km north of Toker Point	Area proposed as a National Site of Canadian Significance; no ocean dumping would be permitted if the area was declared a Canadian Landmark, but no such proposal is currently contemplated.
Inuvialuit Settlement Region	Canadian Beaufort Sea	Canadian Government is committed consult before making decisions in this region which affect Inuvialuit rights.
Northern Land Use Planning	Canadian Beaufort Sea	A Land Use Planning Commission has been established and dumpsite selection should be compatible with any plan which will be produced for the Beaufort Sea

8. OIL AND GAS DEVELOPMENT SITES

Figure 7 illustrates the location of the recommended ocean dumpsite in relation to past exploration drilling activities in the Beaufort Sea. The dumpsite would not be located in the immediate vicinity of previous exploration wellsites. As well, the dumpsite will probably not interfere with drilling in the near future since the limitations of existing Beaufort Sea drilling technology have to date precluded drilling in depths greater than 100m. However, the site is located on the boundary of an oil and gas lease block (EA210 held by Placid Northern Oils Ltd.), and deep-water (100+m) drilling techniques and equipment derived from East Coast or North Sea drilling experience might allow future exploratory drilling near the proposed site.

9. EFFECTS OF SCRAP METAL DISPOSAL

A primary consideration during the ocean dumpsite selection process has been the potential effects of dumping activities on marine organisms. Of particular concern, have been the possible impacts on "Valued Ecosystem Components" originally identified for the Beaufort Sea Environmental Monitoring Project (Table 4). These components refer to resources or environmental features which:

a) are important to local human populations;
b) have national or international profiles; or
c) are important in evaluating development and in focussing management or regulatory policy (LGL Limited et al., 1984).

It is possible that interactions with whales may occur during the actual dumping operations at the recommended dumpsite. Studies summarized in Dome et al. (1982) indicate that bowhead whales may range north of $70^{0}\ 30'$N latitude between July and September. During the same period, however, white whales tend to congregate near the mouth of the Mackenzie River and occassionally in Kugmallit Bay. Underwater noise, vessel movements, and increased turbidity may cause avoidance responses in white and bowhead whales. These effects could, however, be mitigated through careful scheduling of dumping activities. At a depth of 200 metres, it is very unlikely that inert bulky materials would have any adverse effects on whales.

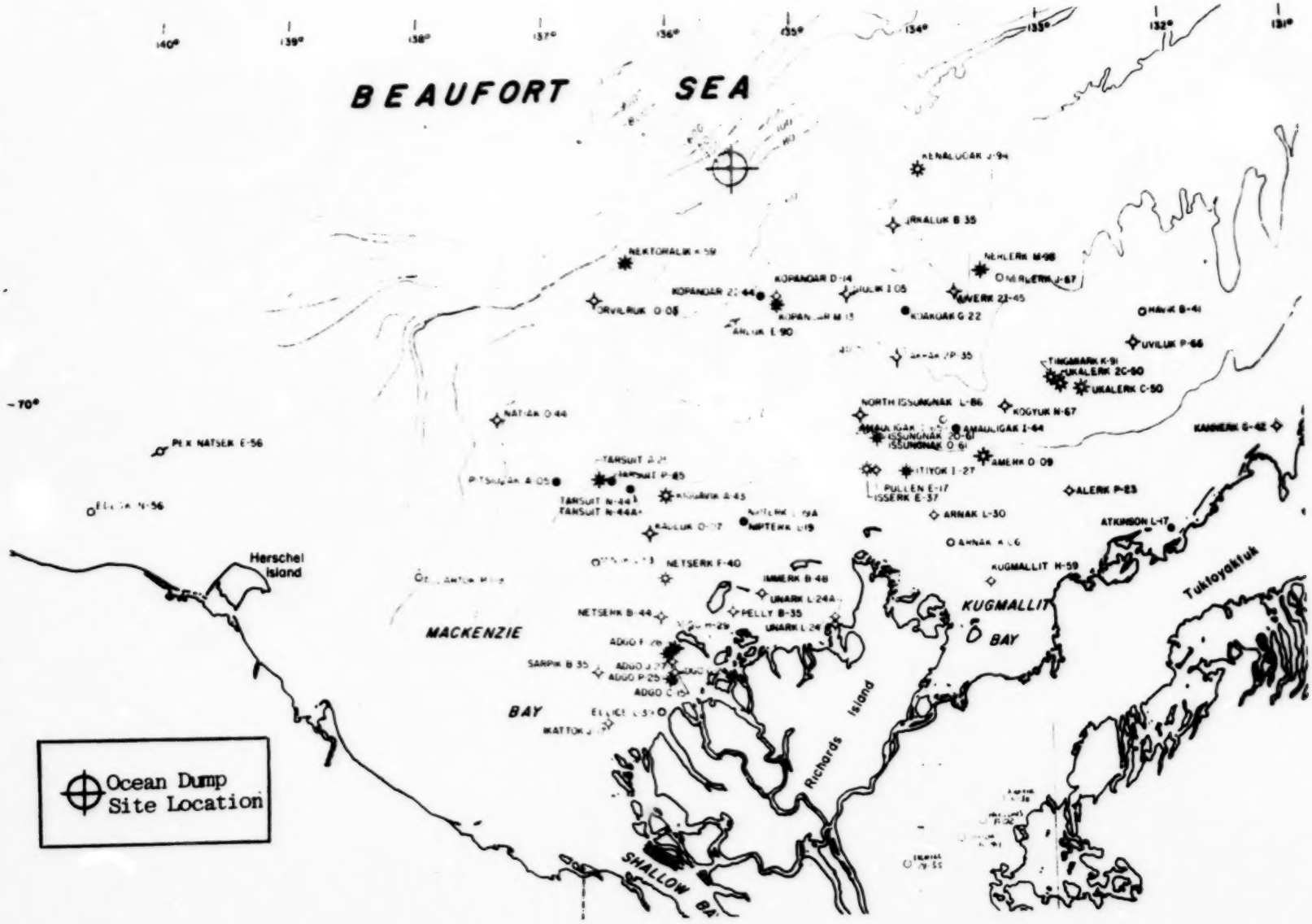


Figure 7.Potential Ocean Dumpsite Location in Relation to Past Hydrocarbon Exploration Activities.

TABLE 4: VALUED ECOSYSTEM COMPONENTS FOR THE BEAUFORT SEA REGION

- white (Beluga) whale
- bowhead whale
- ringed seal
- bearded seal
- polar bear
- common eider
- king eider
- diving ducks (oldsquaw, scoters, scaups)
- thick-billed murre
- brant
- lake whitefish
- broad whitefish
- least cisco
- arctic cisco
- arctic char

Source: LGL Limited et al., 1984

Bird species listed in Table 4 tend to utilize nearshore and onshore areas during summer months and are not expected to frequent waters near the potential dumpsite (Dome et al., 1982). Similarly, seals tend to frequent ice-free areas shallower than 50m (Renaud and Davis, 1981; Stirling et al., 1981a) during the summer. Polar bears are typically restricted to areas where sea ice occurs throughout most of the year and should not be present at the dumpsite during open water periods (Stirling et al., 1981b). If polar bears are present on ice in the area, the only interaction which could occur would be limited to an encounter during dumping operations. It is expected that polar bears would be deterred without being harmed.

Valued fish species listed in Table 4 will be largely unaffected by scrap metal disposal activities. Although these fish frequent marine waters during their life-cycle, various studies suggest that they are restricted to nearshore waters during summer months (Byers and Kashino, 1980; Craig and Haldorson, 1980; Lawrence et al., 1984). A series of bottom trawls carried out during the August 1986 dumpsite characterization study captured Polar and Arctic cod, eelpouts, sculpins, snailfish, leatherfin lump-suckers, Arctic alligatorfish, and a skate (Arctic Laboratories Limited, 1987). None of the valued species were represented in the catch. Based on these findings, valued fish species are not expected to frequent the selected dumpsite area during the period when dumping activities are likely to occur.

Limited effects on resident demersal fish could result from the destruction of benthic prey species in the immediate dumping area. However, increased cover provided by the dumped material and increased benthic production and prey availability (stemming from colonization of hard substrates by benthic invertebrates) might actually enhance local fish populations.

Benthic organisms would be most seriously affected by dumping activities, albeit in a very localized area. Organisms which could be affected include worms, snails, crabs, clams, sea stars, arthropods, sea anemones, and sea squirts (Arctic Laboratories Limited, 1987). These fauna and their benthic habitats would be impacted at the points where dumped wastes settle on the substrate. Following the dumping of waste material, a short-lived increase in turbidity could also occur around the impact zone. Any reduction of benthic habitat, however, would likely be offset to some degree by the increased availability of hard substrates which would be colonized by suitably-adapted species such as sea-anemones.

Changes in water quality parameters would not be expected to occur.

10. COST OF OCEAN DISPOSAL

Most of the scrap metal to be disposed of by ocean dumping is presently stored in industry yards at or near Tuktoyaktuk. Environmental Protection (1986) has estimated the costs of hauling scrap metal from Tuktoyaktuk using an oilfield supply vessel or barge as a carrier vessel. The base cost for ocean dumping activities was assessed at $21,000 plus $7,000 for each 50 km traversed to and from the dumpsite. Using these estimates, each trip to the recommended dumpsite (147 km northwest of Tuktoyaktuk) would cost the operator at least $63,000. These costs could increase substantially if adverse ice conditions are encountered. Costs for alternate means of scrap metal disposal (ie. storage, land disposal, or barging salvageable material to a southern location) were not available at the time of writing, although these are normally considered each time an application for an ocean dumping permit is assessed.

11. SUMMARY AND RECOMMENDATIONS

The intent of this report has been to provide an overview of all factors considered during the ocean dumpsite selection process and to provide a rationale for the Pullen location as an offshore waste disposal site. It has also summarized the types and quantities of inert materials to be dumped, the physical and oceanographic characteristics of the potential dumpsite, and the environmental effects of ocean dumping.

Conclusions and recommendations contained herein are based on the premise that any inert materials identified for disposal at ocean sites would have to be acceptable wastes according to conditions outlined in the Ocean Dumping Control Act. The recommended dumpsite should be ice-free for fifty percent of the time between the first week of August and the first week of October. The dumpsite is located near the upper edge of the continental slope at depths sufficient to allow unrestricted surface vessel travel. Wind and near-bottom current data are not presently available for the specific ocean dumpsite, but existing bottom current measurements indicate that mean velocities range between 7.4 and 10.8 cm/s and maximum velocities reach between 22.6 and 40.9 cm/s in the general vicinity of the recommended site. These maximum currents are not expected to be strong enough to remobilize bulky materials, although uncrushed steel drums could be rolled.

Environmental effects are expected to be localized and short-lived, although some activities associated with ocean dumping could elicit an avoidance response among bowhead and white whales.

Benthic invertebrates will be impacted only in the immediate area where dumped wastes settle on the substrate. Increased turbidity and sediment re-suspension following dumping activities could also affect benthic fauna near the impact zone. Demersal fish populations in the dumpsite area might be affected by the loss of prey species, although these negative effects would likely be offset by invertebrate colonization of hard substrates and the greater cover provided by dumped materials. Positive and negative impacts on regional populations of benthic fauna and demersal fish would not be significant. Valued fish species are not expected to frequent the dumpsite area during periods when dumping is likely to occur.

It is recommended that:

a) the Pullen site (70° 39'N; 135° 50'W) be considered when applications to ocean dump bulky inert materials such as scrap metal are put forward;

b) dumping take place from a barge or oilfield supply vessel during the open-water season;

c) oil drums and other barrels be crushed to avoid the potential for displacement by currents;

d) the material be carefully released from a stationary vessel to minimize the zone of impact, and that subsequent loads be offset-dumped to avoid disrupting benthos and fish which have colonized previously dumped material and to ensure that a high pile of material is not created;

e) where possible, dumping be scheduled to avoid interactions with bowhead and white whales; and

f) regular post-disposal surveys, using photography, video recording, grab and/or core sampling, and side-scan sonar, be undertaken to monitor for environmental changes.

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